3D Gaussian Splatting for Learned Drone Navigation

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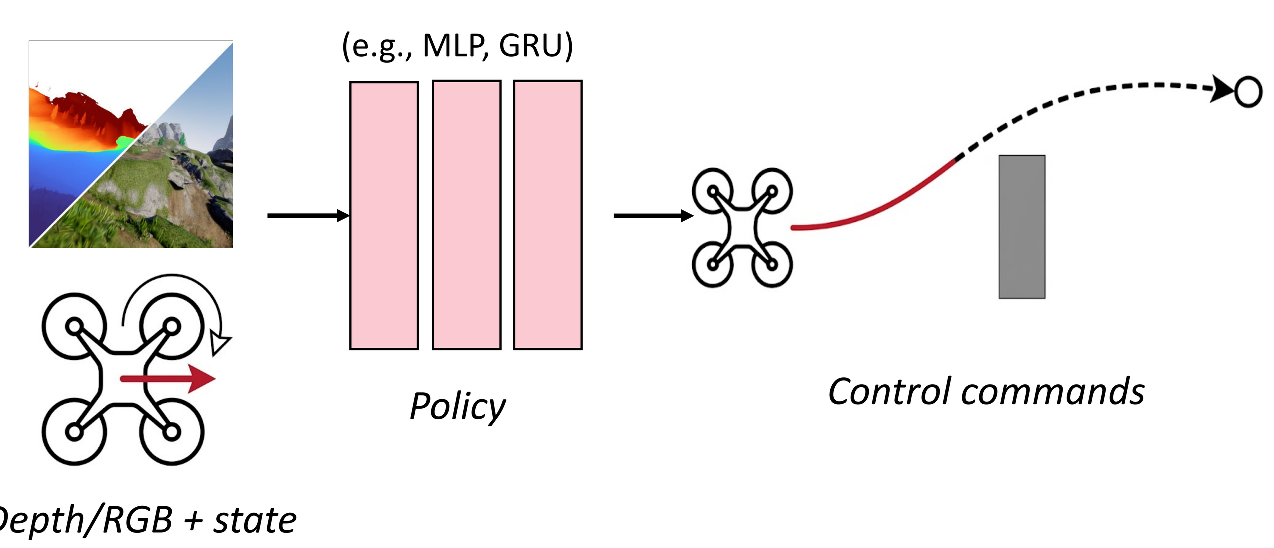
Introduction

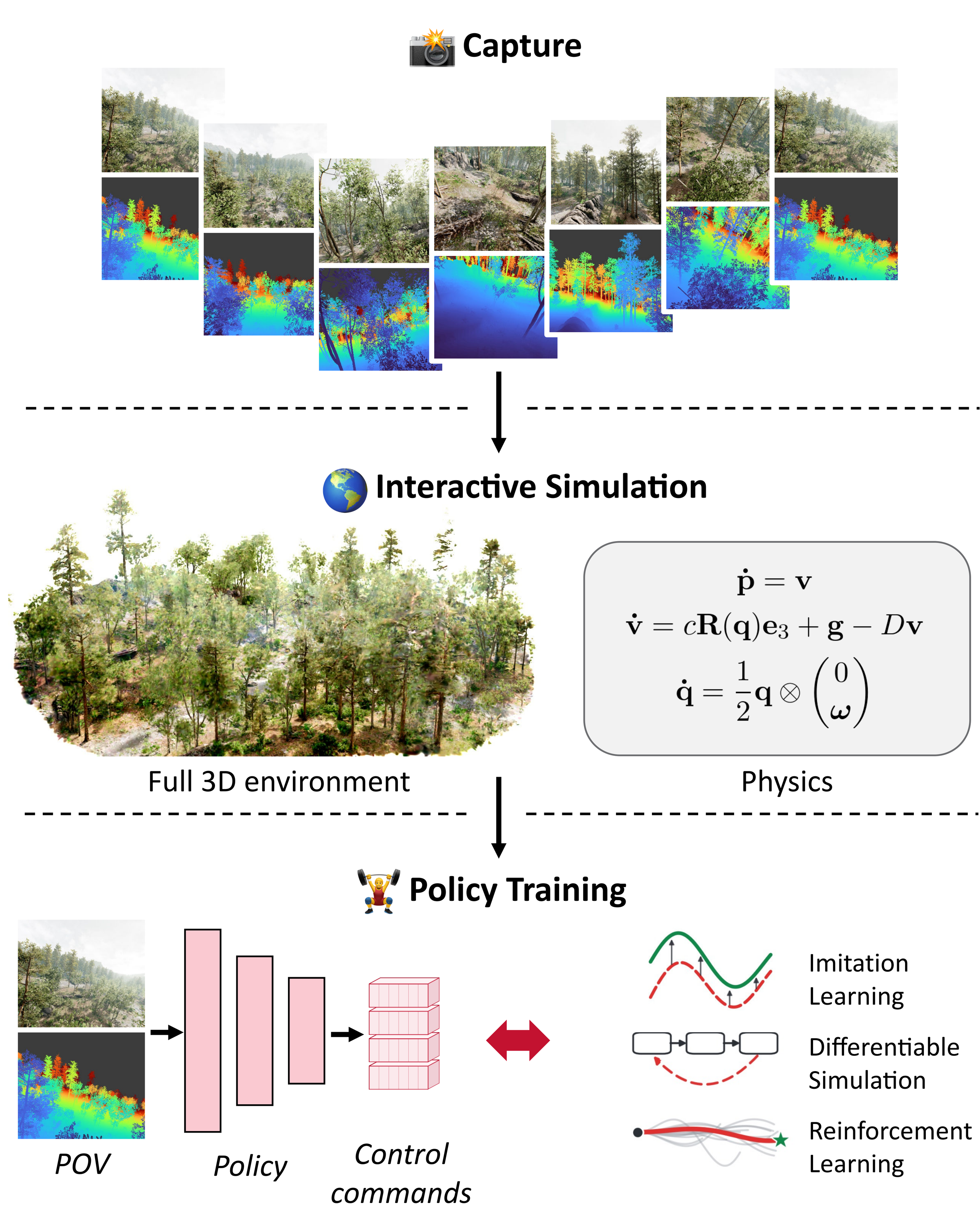
Goal: lightweight end-to-end navigation policy for agile drone flight in the wild.



Current policies use **depth** because it is appearance-invariant. But depth sensors add payload, power, and cost.

Contribution: A simulator to train a monocular RGB policy on a diverse set of scenes.

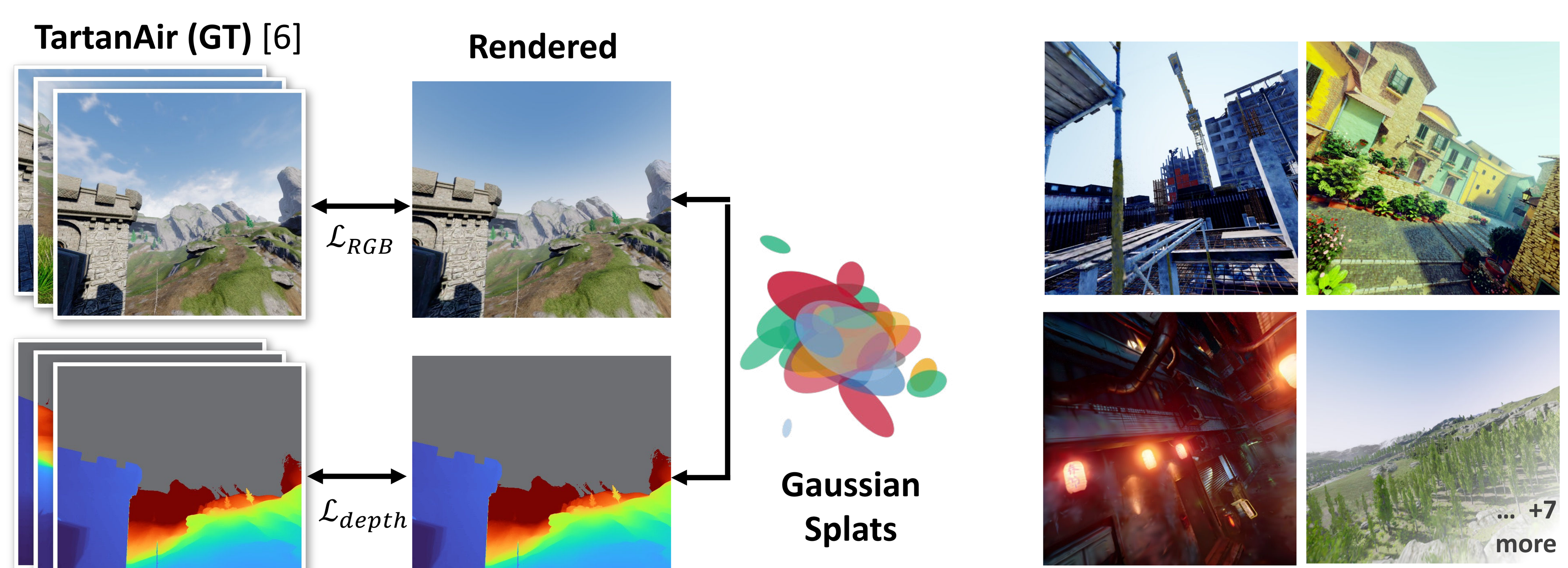
Simulator



$$\dot{\mathbf{p}} = \mathbf{v}$$
$$\dot{\mathbf{v}} = c\mathbf{R}(\mathbf{q})\mathbf{e}_3 + \mathbf{g} - D\mathbf{v}$$
$$\dot{\mathbf{q}} = \frac{1}{2}\mathbf{q} \otimes \begin{pmatrix} 0 \\ \omega \end{pmatrix}$$

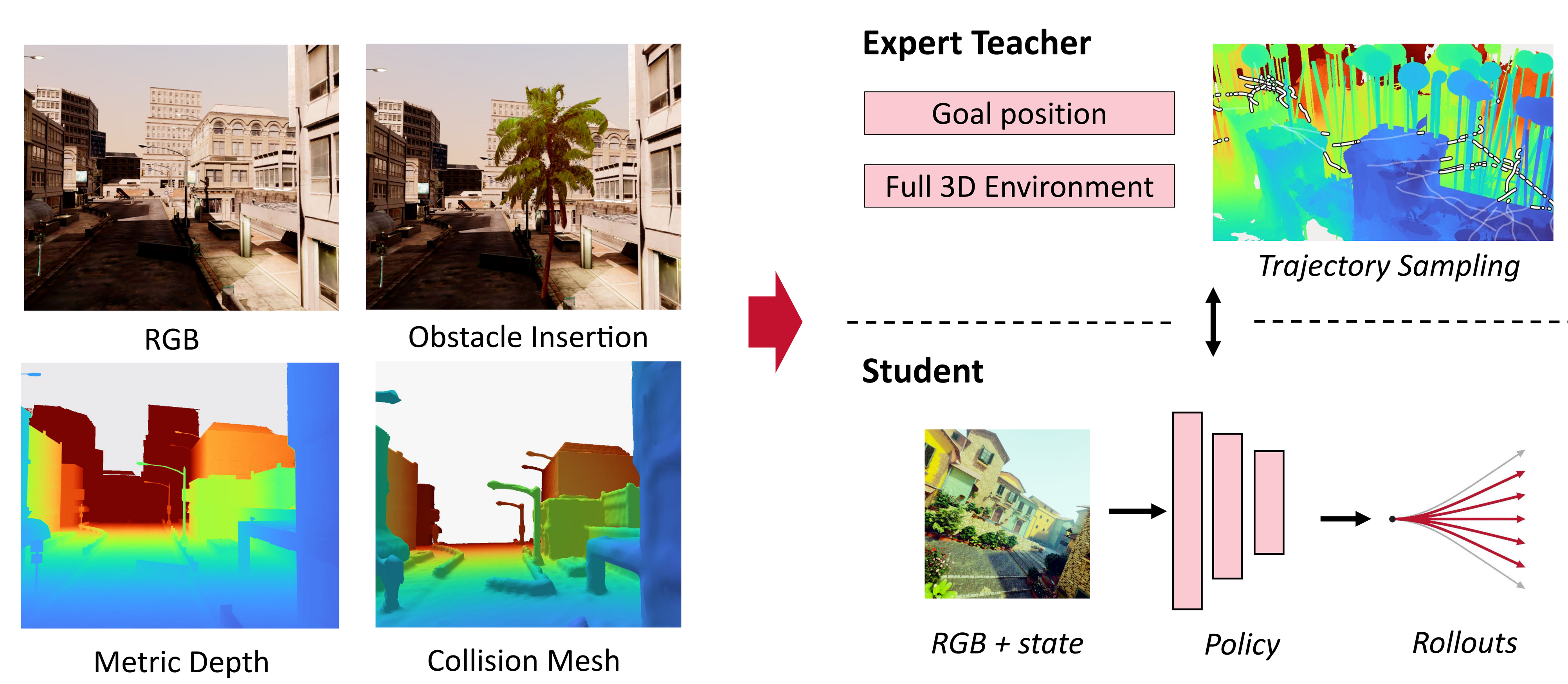
Methods

Use 3DGS as a simulation environment

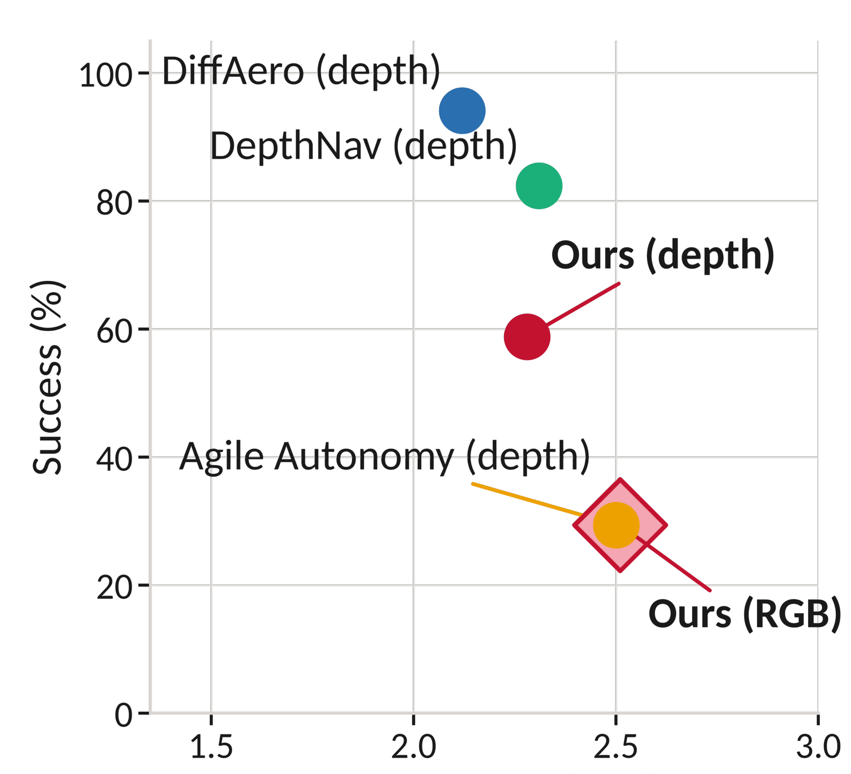


Trained 10 diverse scenes

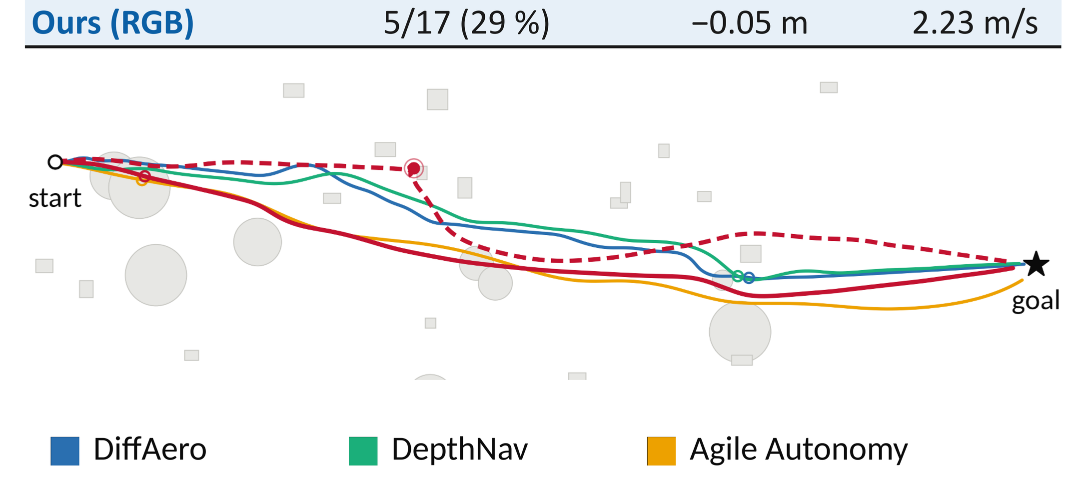
Imitation Learning inside 3DGS environment



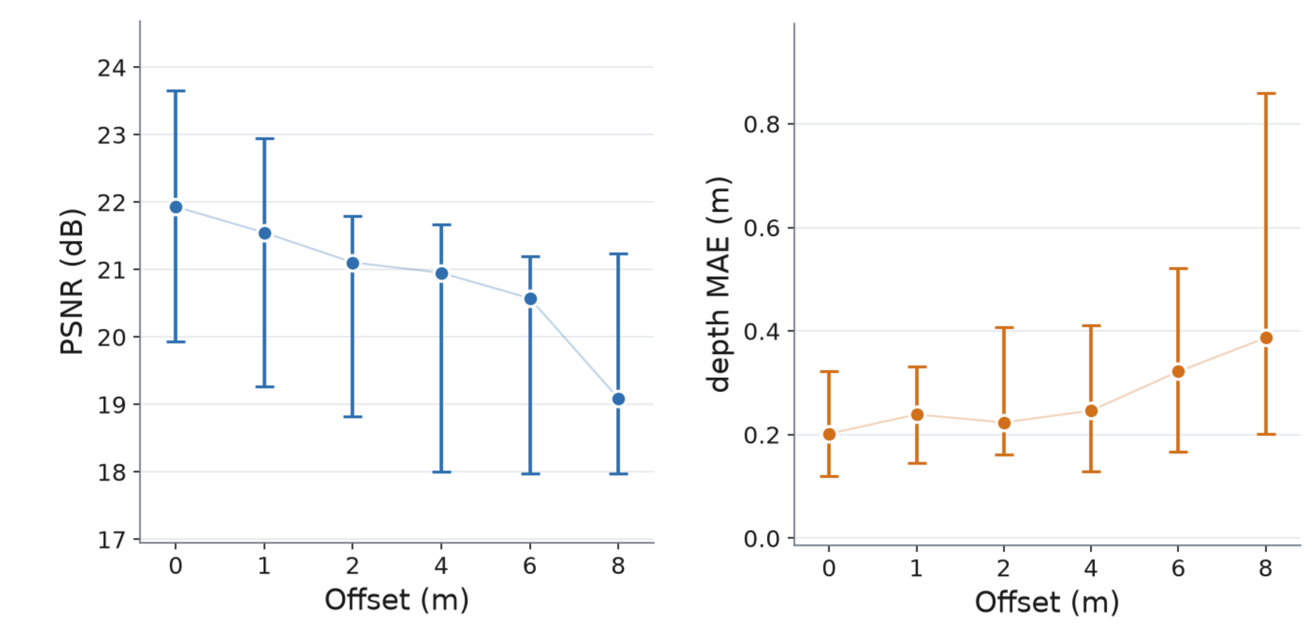
Results



Method	Success Rate ↑	Min-clearance ↑	Avg vel
DiffAero [1]	**16/17 (94 %)**	**+0.37 m**	2.12 m/s
DepthNav [2]	14/17 (82 %)	+0.30 m	2.31 m/s
Agile Autonomy [3]	5/17 (29 %)	−0.01 m	2.50 m/s
Ours (Depth)	10/17 (59 %)	+0.33 m	2.28 m/s
Ours (RGB)	5/17 (29 %)	−0.05 m	2.23 m/s



Qualitative Results



Method	Rendering Quality			Geometric Fidelity	
	PSNR ↑	SSIM ↑	LPIPS ↓	Depth MAE (m) ↓	Floaters ↓
Vanilla 3DGS [4]	**29.35**	0.8706	0.215	0.974	11.5 %
Vanilla 2DGS [5]	29.07	0.8656	0.228	1.466	13.0 %
2DGS + depth	28.93	0.8664	0.224	0.124	0.6 %
3DGS + depth (ours)	29.10	**0.8729**	0.209	0.087	0.4 %

Future Work

- **Evaluate sim-to-real transfer:** Deploy trained RGB policy on a physical quadrotor.
- Extend 3DGS scene reconstruction beyond TartanAir to **broader real-world data**.
- More training methods beyond imitation learning.

Acknowledgements

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References: [1] Zhang et al., DiffAero, 2025. [2] Lee et al., DepthNav, 2025. [3] Loquercio et al., High-Speed Flight in the Wild, Sci. Robot. 2021. [4] Kerbl et al., 3D Gaussian Splatting, SIGGRAPH 2023. [5] Huang et al., 2D Gaussian Splatting, SIGGRAPH 2024. [6] Wang et al., TartanAir, IROS 2020.